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(54) **Header Object Protection for a Data Stream**

(57) A header object for a data file is comprised of sub-objects which specify properties of the data stream and contains information needed to properly verify and interpret the information within the data object. In order to allow the protection of any set of sub-objects without requiring that the sub-objects follow any specific ordering, a new sub-object is introduced which includes region specifiers identifying regions within sub-objects and verification information for those regions. This new sub-object in the header object allows the modification of non-protected regions and reorganization of sub-objects in a header without invalidating verification information.

For example, one data stream format is the Advanced Streaming Format (ASF), which is an extensible file format designed to store coordinate multimedia data.

Digital Signature Sub-Object 500

GUID 510
Size of Digital Signature Sub-Object 520
Number of Signed Regions 530
Region Specifier Array 540
Checksum Algorithm Identifier 550
Signature Algorithm Identifier 560
Signature Length 570
Signature 580
Signer Information 590

FIG. 5

Description

Field of the Invention:

[0001] The present invention relates generally to data verification, and more particularly to a header object for a data file.

Background of the Invention:

[0002] Conventionally, some data file and data stream formats include header objects. The header object includes "meta-content" information used for identifying and using the content data included in the data file or data stream.

[0003] For example, one data stream format is the Advanced Streaming Format (ASF), which is an extensible file format designed to store coordinated multimedia data. The current specification for this format is available from www.microsoft.com. ASF supports data delivery over a wide variety of networks and protocols while allowing for local playback.

[0004] Each ASF file is composed of one or more media streams. The header object specifies the properties of the entire file, along with stream-specific properties. In ASF, each file must have one header object. The header object provides a well-known byte sequence at the beginning of ASF files (the header object GUID (globally unique identifier)) and to contain all the information needed to properly interpret the multimedia data. The header object may be thought of as a container that contains header object information and a combination of header sub-objects. The header object information consists of a GUID for the header object ("ASF_Header_Object"), the size of the header object, and the number of header sub-objects contained in the header object. Each header object begins with a GUID.

[0005] Header sub-objects include:

- A file properties sub-object, which defines the global characteristics of the multimedia data in the file;
- A stream properties sub-object, which defines the specific properties and characteristics of a media stream;
- The header extension sub-object, which allows additional functionality to be added to an ASF file while maintaining backwards compatibility, and is a container containing extended header sub-objects;
- The codec list sub-object, which provides user-friendly information about the codecs and formats used to encode the content found in the ASF file;
- The script command sub-object, which provides a list of type/parameter pairs of Unicode strings that are synchronized to the ASF file's timeline;
- The marker sub-object, which contains a small, specialized index that is used to provide named jump points within a file to allow a content author to divide content into logical sections, such as song

boundaries in an entire CD or topic changes during a long presentation, and to assign a human-readable name to each section of a file for use by the user;

- The bitrate mutual exclusion sub-object, which identifies video streams that have a mutual exclusion relationship to each other (in other words, only one of the streams within such a relationship can be streamed and the rest are ignored);
- The error correction sub-object, which defines the error correction method and provides information needed by the error correction engine for recovery;
- The content description sub-object, which permits authors to record well-known data describing the file and its contents, including title, author, copyright, description, and rating information;
- The extended content description sub-object, which permits authors to record data describing the file and its contents that is beyond the standard bibliographic information such as title, author, copyright, description, or rating information;
- The content encryption sub-object, which identifies if the content is protected by a digital rights management (DRM) system. This sub-object includes the DRM license-acquisition URL, the DRM Key ID, and other DRM-related metadata.
- The stream bitrate properties sub-object, which defines the average bitrate of each media stream in the multimedia data; and
- A padding sub-object, which is a dummy sub-object used to pad out the size of the header object.

[0006] The entity which first creates the data stream file and any successive entities acting on it may add or change elements of the header file. For example, a content-creating entity may create a data stream file, and include information in the content description object regarding the content. A second entity may create markers within the data, and wish to add a marker object with track information. And a third entity, which distributes the data stream file, may add a script command object containing actions or data for scripts. For example, a script command object may contain information that opens a web browser window to a specified URL (uniform resource locator).

[0007] Because a number of entities may act on an ASF file, there is no way to determine which entity has created which part of the header object. Additionally, a change of information by an attacker cannot be identified.

Summary Of The Invention:

[0008] The present invention is directed to a system, method, and data structure for the verification of sub-objects in a header object. The invention allows for verification by one entity of one or more sub-objects in the header object while still allowing the ordering of sub-ob-

jects to change. New sub-objects can also subsequently be created and verified by another entity. The verification of two or more sub-objects by a trusted entity may be combined, so that an attacker can not remove or change data leaving one sub-object verifiable as having been signed by the trusted entity while the other sub-object is not verifiable.

[0009] Additional features and advantages of the invention are set forth in the description below.

Brief Description Of The Figures:

[0010]

FIG. 1 is a diagram illustrating an overview of a computer system.

FIG. 2 is a block diagram illustrating a file according to the invention.

FIG. 3 illustrates the process of creating a digital signature sub-object according to the invention.

FIG. 4 illustrates the process of verifying a digital signature sub-object according to the invention.

FIG. 5 illustrates a digital signature sub object according to the invention.

Detailed Description Of The Preferred Embodiments:

Overview

[0011] One or more digital signature sub-objects can be created and placed in the header object of a data file to allow for signature information for sub-objects and regions of sub-objects in the header object. If a digital signature sub-object is present and valid, any editing or tampering with the signed sub-objects can be detected. Ordering of the sub-objects need not be preserved.

[0012] The digital signature sub-object contains an array of region specifiers. Each region specifier identifies a specific region within a sub-object. A region specifier may also identify a complete sub-object.

[0013] The digital signature sub-object also contains a signature. The signature is a digital signature of the regions listed in the array of region specifiers. The signature can be used to verify that the regions listed in the region specifier array have not been tampered with.

Exemplary Computing Environment

[0014] FIG. 1 illustrates an example of a suitable computing system environment 100 in which the invention may be implemented. The computing system environment 100 is only one example of a suitable computing environment and is not intended to suggest any limitation as to the scope of use or functionality of the invention. Neither should the computing environment 100 be interpreted as having any dependency or requirement relating to any one or combination of components illus-

trated in the exemplary operating environment 100.

[0015] One of ordinary skill in the art can appreciate that a computer or other client or server device can be deployed as part of a computer network, or in a distributed computing environment. In this regard, the present invention pertains to any computer system having any number of memory or storage units, and any number of applications and processes occurring across any number of storage units or volumes, which may be used in connection with the present invention. The present invention may apply to an environment with server computers and client computers deployed in a network environment or distributed computing environment, having remote or local storage. The present invention may also be applied to standalone computing devices, having programming language functionality, interpretation and execution capabilities for generating, receiving and transmitting information in connection with remote or local services.

[0016] The invention is operational with numerous other general purpose or special purpose computing system environments or configurations. Examples of well known computing systems, environments, and/or configurations that may be suitable for use with the invention include, but are not limited to, personal computers, server computers, hand-held or laptop devices, multiprocessor systems, microprocessor-based systems, set top boxes, programmable consumer electronics, network PCs, minicomputers, mainframe computers, distributed computing environments that include any of the above systems or devices, and the like.

[0017] The invention may be described in the general context of computer-executable instructions, such as program modules, being executed by a computer. Generally, program modules include routines, programs, objects, components, data structures, etc. that perform particular tasks or implement particular abstract data types. The invention may also be practiced in distributed computing environments where tasks are performed by remote processing devices that are linked through a communications network or other data transmission medium. In a distributed computing environment, program modules and other data may be located in both local and remote computer storage media including memory storage devices. Distributed computing facilitates sharing of computer resources and services by direct exchange between computing devices and systems. These resources and services include the exchange of information, cache storage, and disk storage for files. Distributed computing takes advantage of network connectivity, allowing clients to leverage their collective power to benefit the entire enterprise. In this regard, a variety of devices may have applications, objects or resources that may utilize the techniques of the present invention.

[0018] With reference to FIG. 1, an exemplary system for implementing the invention includes a general-purpose computing device in the form of a computer 110.

Components of computer 110 may include, but are not limited to, a processing unit 120, a system memory 130, and a system bus 121 that couples various system components including the system memory to the processing unit 120. The system bus 121 may be any of several types of bus structures including a memory bus or memory controller, a peripheral bus, and a local bus using any of a variety of bus architectures. By way of example, and not limitation, such architectures include Industry Standard Architecture (ISA) bus, Micro Channel Architecture (MCA) bus, Enhanced ISA (EISA) bus, Video Electronics Standards Association (VESA) local bus, and Peripheral Component Interconnect (PCI) bus (also known as Mezzanine bus).

[0019] Computer 110 typically includes a variety of computer readable media. Computer readable media can be any available media that can be accessed by computer 110 and includes both volatile and nonvolatile media, removable and non-removable media. By way of example, and not limitation, computer readable media may comprise computer storage media and communication media. Computer storage media includes both volatile and nonvolatile, removable and non-removable media implemented in any method or technology for storage of information such as computer readable instructions, data structures, program modules or other data. Computer storage media includes, but is not limited to, RAM, ROM, EEPROM, flash memory or other memory technology, CDROM, digital versatile disks (DVD) or other optical disk storage, magnetic cassettes, magnetic tape, magnetic disk storage or other magnetic storage devices, or any other medium that can be used to store the desired information and that can be accessed by computer 110. Communication media typically embodies computer readable instructions, data structures, program modules or other data in a modulated data signal such as a carrier wave or other transport mechanism and includes any information delivery media. The term "modulated data signal" means a signal that has one or more of its characteristics set or changed in such a manner as to encode information in the signal. By way of example, and not limitation, communication media includes wired media such as a wired network or direct-wired connection, and wireless media such as acoustic, RF, infrared and other wireless media. Combinations of any of the above should also be included within the scope of computer readable media.

[0020] The system memory 130 includes computer storage media in the form of volatile and/or nonvolatile memory such as read only memory (ROM) 131 and random access memory (RAM) 132. A basic input/output system 133 (BIOS), containing the basic routines that help to transfer information between elements within computer 110, such as during start-up, is typically stored in ROM 131. RAM 132 typically contains data and/or program modules that are immediately accessible to and/or presently being operated on by processing unit 120. By way of example, and not limitation, FIG. 1 illus-

trates operating system 134, application programs 135, other program modules 136, and program data 137.

[0021] The computer 110 may also include other removable/non-removable, volatile/nonvolatile computer storage media. By way of example only, FIG. 1 illustrates a hard disk drive 140 that reads from or writes to non-removable, nonvolatile magnetic media, a magnetic disk drive 151 that reads from or writes to a removable, nonvolatile magnetic disk 152, and an optical disk drive 155 that reads from or writes to a removable, nonvolatile optical disk 156, such as a CD ROM or other optical media. Other removable/non-removable, volatile/nonvolatile computer storage media that can be used in the exemplary operating environment include, but are not limited to, magnetic tape cassettes, flash memory cards, digital versatile disks, digital video tape, solid state RAM, solid state ROM, and the like. The hard disk drive 141 is typically connected to the system bus 121 through an non-removable memory interface such as interface 140, and magnetic disk drive 151 and optical disk drive 155 are typically connected to the system bus 121 by a removable memory interface, such as interface 150.

[0022] The drives and their associated computer storage media discussed above and illustrated in FIG. 1, provide storage of computer readable instructions, data structures, program modules and other data for the computer 110. In FIG. 1, for example, hard disk drive 141 is illustrated as storing operating system 144, application programs 145, other program modules 146, and program data 147. Note that these components can either be the same as or different from operating system 134, application programs 135, other program modules 136, and program data 137. Operating system 144, application programs 145, other program modules 146, and program data 147 are given different numbers here to illustrate that, at a minimum, they are different copies. A user may enter commands and information into the computer 20 through input devices such as a keyboard 162 and pointing device 161, commonly referred to as a mouse, trackball or touch pad. Other input devices (not shown) may include a microphone, joystick, game pad, satellite dish, scanner, or the like. These and other input devices are often connected to the processing unit 120 through a user input interface 160 that is coupled to the system bus, but may be connected by other interface and bus structures, such as a parallel port, game port or a universal serial bus (USB). A monitor 191 or other type of display device is also connected to the system bus 121 via an interface, such as a video interface 190. In addition to the monitor, computers may also include other peripheral output devices such as speakers 197 and printer 196, which may be connected through an output peripheral interface 190.

[0023] The computer 110 may operate in a networked environment using logical connections to one or more remote computers, such as a remote computer 180. The remote computer 180 may be a personal computer, a

server, a router, a network PC, a peer device or other common network node, and typically includes many or all of the elements described above relative to the computer 110, although only a memory storage device 181 has been illustrated in FIG. 1. The logical connections depicted in FIG. 1 include a local area network (LAN) 171 and a wide area network (WAN) 173, but may also include other networks. Such networking environments are commonplace in offices, enterprise-wide computer networks, intranets and the Internet.

[0024] When used in a LAN networking environment, the computer 110 is connected to the LAN 171 through a network interface or adapter 170. When used in a WAN networking environment, the computer 110 typically includes a modem 172 or other means for establishing communications over the WAN 173, such as the Internet. The modem 172, which may be internal or external, may be connected to the system bus 121 via the user input interface 160, or other appropriate mechanism. In a networked environment, program modules depicted relative to the computer 110, or portions thereof, may be stored in the remote memory storage device. By way of example, and not limitation, FIG. 1 illustrates remote application programs 185 as residing on memory device 181. It will be appreciated that the network connections shown are exemplary and other means of establishing a communications link between the computers may be used.

Digital Signature Sub-Objects

[0025] Where a header object includes sub-objects and regions of sub-objects to be protected, according to the invention, a digital signature sub-object may be added to the header in order to allow verification that the sub-objects and regions signed have not been tampered with. This digital signature sub-object may be based on any digital signing algorithm that takes as input some data and produces a signature that can later be verified. In one embodiment, the algorithm used is the RSA algorithm. In another embodiment, the elliptic curve algorithm is used. Other embodiments may use other signature algorithms.

[0026] Referring to FIG. 2, file 200 contains a header object 210. In addition to header information 215, header object 210 contains a file properties sub-object 220, a stream properties sub-object 230, a script command sub-object 240, and content description sub-object 250. Content description sub-object 250 contains information on title 252, author 254, copyright 256 and description 258 of the content. Script command sub-object 240 contains a URL 245. File 200 also contains data object 290. This figure is exemplary, and it will be recognized that other combinations of sub-objects may be present in the header object rather than those shown.

[0027] An entity may prevent tampering with parts of the header object 210 by adding digital signature sub-object 260. Digital signature sub-object 260 contains re-

gion specifier array 264 and signature 266. In one embodiment, digital signature sub-object 260 also contains signer information 268. In one embodiment, signer information 268 contains one or more certificates which can be used to securely verify the signature 266.

[0028] The process for creating a digital signature sub-object 260 is shown in FIG. 3. As shown in step 310, the entity decides which one or more regions of header sub-objects it is going to sign and determines the region specifiers for these regions. For example, with reference to FIG. 2, the regions to be signed may include the script command sub-object 230 and the title, author, and copyright sections of the content description sub-object 250. Referring again to FIG. 3, in step 320, the region specifier array 264 (from FIG. 2) is created. In step 330, the regions specified in the region specifier array 264 are concatenated (in the order in which they are specified in the region specifier array 264) along with the region specifier array 264. This region is then signed 340 to produce signature 266 (from FIG. 2).

[0029] When a file containing a header object including a digital signature sub-object is modified, the order of the sub-objects may be changed and additional sub-objects may be inserted. If additional regions or sub-objects are to be verified, a new digital signature sub-object may be added.

[0030] With reference to FIG. 2, in order to check the verification of the header object 210, the digital signature sub-object 260 and the regions specified in the region specifier array 264 are used. As shown in FIG. 4, step 410, the header sub-object regions specified in the region specifier array 264 (from FIG. 2) are identified. In step 420, these regions are concatenated (in the order in which they are specified in the region specifier array 264) together with the region specifier array 264. In step 430, signature 266 (from FIG. 2) is checked to determine whether it is a valid signature for the concatenation.

[0031] In one embodiment of the invention, both regions of sub-objects and complete sub-objects may be signed using the digital signature sub-object. In another embodiment, only complete sub-objects may be signed. In one embodiment of the invention, more than one region from a single sub-object may be signed in one digital signature sub-object. In one embodiment of the invention, the regions of one sub-object being signed may overlap.

[0032] In one embodiment of the invention, each header object must contain at least one digital signature sub-object. If the header object does not contain a digital signature sub-object when one is expected, then it can be assumed that the header object has been tampered with. If the header object contains a digital signature sub-object that does not verify correctly or is not from a trusted source, the entity receiving the file containing the header object may act accordingly, for example, in one implementation, by not using the file. According to this embodiment, a check is performed to see if any digital signature sub-objects exist. If none exist, then verifica-

tion fails. If sub-objects do exist, each one is checked to yield a verification result.

[0033] In one embodiment, any file F that is a collection of objects O_1, O_2, \dots, O_n may be signed according to the invention. A new object O_{DS} is created which includes a region specifier array specifying the objects or regions of objects signed and a signature for those objects and the array.

Exemplary ASF Implementation

[0034] In one embodiment, the file is an ASF file. The components of a digital signature sub-object for an ASF file, in one embodiment, is shown in FIG. 5. Digital signature sub-object 500 includes a GUID 510. Each object and sub-object in an ASF file begins with a GUID. GUIDs are used to uniquely identify all objects types within ASF files. Each ASF object type has its own unique GUID. However, in general, GUIDs cannot be used to uniquely identify sub-objects within an ASF Header object since multiple sub-objects in an ASF Header object may have the same object type, and thus have the same GUID.

[0035] The next element in the exemplary ASF digital signature sub-object 500 is the sub-object size 520. Again, all ASF objects and sub-objects generally include the size of the object and sub-object. The region specifier array 540, as described above, is preceded by the number of signed regions contained in the region specifier array 530. The checksum algorithm identifier 550 and the signature algorithm identifier 560 identify the checksum and signature algorithms used in the digital signature sub-object. The signature 580 of the regions and the region specifier array is preceded by the length of the signature 570. Signer information 590 contains information needed to verify or obtain information regarding the signer. Signer information 590 may include the identity of the signer. In one embodiment, signer information 590 contains a certificate chain that can be used to verify the public key of the signer is from a trusted source.

[0036] In the exemplary ASF implementation, each region specifier contains a sub-object region offset, a sub-object region size, a checksum length and an object checksum. The region offset identifies where the region starts in the sub-object, and the region size identifies the size of the region. The object checksum corresponds to the checksum of the region specified. This checksum algorithm, in a preferred embodiment, is the Secure Hash Algorithm (SHA-1) algorithm. This algorithm is available in the Federal Information Processing Standards Publication 180-1, which is available on the Internet at <http://www.itl.nist.gov/fipspubs/fip180-1.htm>. In alternate embodiments, any hashing algorithm with a low probability of collision can be used. In an alternate embodiment, the object checksum corresponds to the checksum of the sub-object containing the region specified.

[0037] When the signature is being checked, in order

to determine which sub-object the region is located in (as in step 410 of FIG. 4), the header sub-objects are examined. For each sub-object being examined, a checksum is computed according to the algorithm specified in the checksum algorithm identifier 550. In the embodiment where the checksum is computed over the region, a checksum is computed for the data contained in that sub-object which begins at the given sub-object region offset and extends to be the given sub-object region size. In the embodiment where the checksum is computed over the entire sub-object, a checksum is computed for the sub-object. When a checksum is computed which matches the checksum in the region specifier, the correct sub-object for the region specifier has been identified. When a sub-object corresponding to each region specifier has been identified, the signature can be checked.

[0038] In this implementation, in order to specify an entire sub-object to be signed, the offset in the region specifier will be zero, and the region size will be equal to the length of the sub-object. In another embodiment, the checksum is computed for the entire sub-object rather than for the specified region.

[0039] In this embodiment, more than one digital signature sub-object may be included in an object, in order to allow flexibility in having different areas of sub-objects verified together, and having different entities verify sub-objects.

[0040] In other embodiments, other methods may be used to identify the regions. In one embodiment, data which can uniquely identify the sub-object is contained within the region specifier along with region offset and size data.

[0041] In other embodiments, only entire sub-objects may be signed. In one embodiment, the region specifier includes a checksum over the entire sub-object. In another embodiment, the length of the checksum is also included. In yet another embodiment, other data that can identify the sub-object is used in the region specifier.

Conclusion

[0042] Herein a system and method for data stream header object protection. As mentioned above, while exemplary embodiments of the present invention have been described in connection with various computing devices and network architectures, the underlying concepts may be applied to any computing device or system in which it is desirable to provide data stream header object protection. Thus, the techniques for providing data stream header object protection in accordance with the present invention may be applied to a variety of applications and devices. For instance, the techniques of the invention may be applied to the operating system of a computing device, provided as a separate object on the device, as part of another object, as a downloadable object from a server, as a "middle man" between a device or object and the network, as a distributed object,

etc. While exemplary names and examples are chosen herein as representative of various choices, these names and examples are not intended to be limiting.

[0043] The various techniques described herein may be implemented in connection with hardware or software or, where appropriate, with a combination of both. Thus, the methods and apparatus of the present invention, or certain aspects or portions thereof, may take the form of program code (i.e., instructions) embodied in tangible media, such as floppy diskettes, CD-ROMs, hard drives, or any other machine-readable storage medium, wherein, when the program code is loaded into and executed by a machine, such as a computer, the machine becomes an apparatus for practicing the invention. In the case of program code execution on programmable computers, the computing device will generally include a processor, a storage medium readable by the processor (including volatile and non-volatile memory and/or storage elements), at least one input device, and at least one output device. One or more programs that may utilize the techniques of the present invention, e.g., through the use of a data processing API or the like, are preferably implemented in a high level procedural or object oriented programming language to communicate with a computer system. However, the program(s) can be implemented in assembly or machine language, if desired. In any case, the language may be a compiled or interpreted language, and combined with hardware implementations.

[0044] The methods and apparatus of the present invention may also be practiced via communications embodied in the form of program code that is transmitted over some transmission medium, such as over electrical wiring or cabling, through fiber optics, or via any other form of transmission, wherein, when the program code is received and loaded into and executed by a machine, such as an EPROM, a gate array, a programmable logic device (PLD), a client computer, a video recorder or the like, or a receiving machine having the signal processing capabilities as described in exemplary embodiments above becomes an apparatus for practicing the invention. When implemented on a general-purpose processor, the program code combines with the processor to provide a unique apparatus that operates to invoke the functionality of the present invention. Additionally, any storage techniques used in connection with the present invention may invariably be a combination of hardware and software.

[0045] While the present invention has been described in connection with the preferred embodiments of the various figures, it is to be understood that other similar embodiments may be used or modifications and additions may be made to the described embodiment for performing the same function of the present invention without deviating therefrom. For example, while exemplary network environments of the invention are described in the context of a networked environment, such as a peer to peer networked environment, one skilled in

the art will recognize that the present invention is not limited thereto, and that the methods, as described in the present application may apply to any computing device or environment, such as a gaming console, handheld computer, portable computer, etc., whether wired or wireless, and may be applied to any number of such computing devices connected via a communications network, and interacting across the network. Furthermore, it should be emphasized that a variety of computer platforms, including handheld device operating systems and other application specific operating systems are contemplated, especially as the number of wireless networked devices continues to proliferate. Still further, the present invention may be implemented in or across a plurality of processing chips or devices, and storage may similarly be effected across a plurality of devices. Therefore, the present invention should not be limited to any single embodiment, but rather should be construed in breadth and scope in accordance with the appended claims.

Claims

1. A method for use in combination with a digital object comprising at least one sub-object, said method providing a digital signature for at least one region, where each of said at least one region is comprised of all or part of one of said at least one sub-object, and where said sub-objects may be rearranged within the object without invalidating the digital signature, the method comprising:
 - creating an array comprising, for each of said at least one region, a region specifier identifying the region;
 - producing a digital signature based on data comprising each region and said array; and
 - adding a signature sub-object comprising said array and said digital signature to the digital object.
2. The method of claim 1, where each of said at least one region comprises a sub-object from among said at least one sub-objects.
3. The method of claim 1, where each of said region specifiers comprises a checksum calculated according to a checksum algorithm.
4. The method of claim 3, where said checksum is calculated for the region.
5. The method of claim 3, where said checksum is calculated for the sub-object containing the region.
6. The method of claim 3, where said signature sub-object comprises a checksum algorithm identifier

- identifying the checksum algorithm used.
7. The method of claim 3, where each of said region specifiers comprises a checksum length. 5
8. The method of claim 1, where said signature sub-object comprises a signature algorithm identifier identifying a signature algorithm used for said producing of a digital signature. 10
9. The method of claim 1, where said signature sub-object comprises signer identifier identifying a signer for verification of said digital signature.
10. The method of claim 9, where said signer identifier comprises digital certificates for securely identifying and verifying the public key of said signer. 15
11. The method of claim 1, where each of said region specifiers comprises a region offset identifying the start location of the corresponding region in a sub-object. 20
12. The method of claim 1, where each of said region specifiers comprises a region size identifying the size of the corresponding region in a sub-object. 25
13. The method of claim 1, where said object is a header object for an ASF file. 30
14. The method of claim 13, where said new object further comprises a GUID.
15. A method for use in combination with a digital object comprising at least one sub-object, said method validating a digital signature for at least one region, where each of said at least one region is comprised of all or part of one of said at least one sub-object, where an array comprises region specifiers for each of said at least one region, comprising: 35
- identifying a region corresponding to each of said region specifiers;
creating a data object comprising, said array and, for each of said region specifiers, said region corresponding to said region specifier; and
validating said digital signature using on said data object. 45
16. The method of claim 15, where said object is a header object for an ASF file. 50
17. A method for use in combination with a digital object comprising at least one sub-object, said method validating a digital signature for at least one region, where each of said at least one region is comprised of all or part of one of said at least one sub-object, where an array comprises region specifiers for each 55
- of said at least one region, comprising:
- determining the number of digital signatures present in said digital object;
validating each of said digital signatures.
18. The method of claim 17, further comprising:
- returning an error value if the number of digital signatures present in said digital object is zero.
19. A system for use in combination with a digital object comprising at least one sub-object, said system providing a digital signature for at least one region, where each of said at least one region is comprised of all or part of one of said at least one sub-object, and where said sub-objects may be rearranged within the object without invalidating the digital signature, the system comprising:
- array-creation means for creating an array comprising, for each of said at least one region, a region specifier identifying the region;
signing means for producing a digital signature based on data comprising each region and said array; and
signature sub-object adding means for adding a signature sub-object comprising said array and said digital signature to the digital object.
20. The system of claim 19, where each of said at least one region comprises a sub-object from among said at least one sub-objects.
21. The system of claim 19, where each of said region specifiers comprises a checksum calculated according to a checksum algorithm.
22. The system of claim 21, where said checksum is calculated for the region. 40
23. The system of claim 21, where said checksum is calculated for the sub-object containing the region.
24. The system of claim 21, where said signature sub-object comprises a checksum algorithm identifier identifying the checksum algorithm used. 45
25. The system of claim 21, where each of said region specifiers comprises a checksum length.
26. The system of claim 19, where said signature sub-object comprises a signature algorithm identifier identifying a signature algorithm used for said producing of a digital signature.
27. The system of claim 19, where said signature sub-object comprises signer identifier identifying a sign-

er for verification of said digital signature.

28. The system of claim 27, where said signer identifier comprises digital certificates for securely identifying and verifying the public key of said signer.

29. The system of claim 19, where each of said region specifiers comprises a region offset identifying the start location of the corresponding region in a sub-object.

30. The system of claim 19, where each of said region specifiers comprises a region size identifying the size of the corresponding region in a sub-object.

31. The system of claim 19, where said object is a header object for an ASF file.

32. The system of claim 31, where said new object further comprises a GUID.

33. A system for use in combination with a digital object comprising at least one sub-object, said system validating a digital signature for at least one region, where each of said at least one region is comprised of all or part of one of said at least one sub-object, where an array comprises region specifiers for each of said at least one region, comprising:

region-identifying means identifying a region corresponding to each of said region specifiers; data object creation means for creating a data object comprising, said array and, for each of said region specifiers, said region corresponding to said region specifier; and validation means for validating said digital signature using on said data object.

34. The system of claim 33, where said object is a header object for an ASF file.

35. A system for use in combination with a digital object comprising at least one sub-object, said system validating a digital signature for at least one region, where each of said at least one region is comprised of all or part of one of said at least one sub-object, where an array comprises region specifiers for each of said at least one region, comprising:

counting means for determining the number of digital signatures present in said digital object; validating means for validating each of said digital signatures.

36. The system of claim 35, further comprising:

error return means returning an error value if the number of digital signatures present in said

digital object is zero.

37. A computer-readable medium for use in combination with a digital object comprising at least one sub-object, said computer-readable medium providing a digital signature for at least one region, where each of said at least one region is comprised of all or part of one of said at least one sub-object, and where said sub-objects may be rearranged within the object without invalidating the digital signature, computer-readable medium with instructions to perform acts comprising:

creating an array comprising, for each of said at least one region, a region specifier identifying the region; producing a digital signature based on data comprising each region and said array; and adding a signature sub-object comprising said array and said digital signature to the digital object.

38. The computer-readable medium of claim 37, where each of said at least one region comprises a sub-object from among said at least one sub-objects.

39. The computer-readable medium of claim 37, where each of said region specifiers comprises a checksum calculated according to a checksum algorithm.

40. The computer-readable medium of claim 39, where said checksum is calculated for the region.

41. The computer-readable medium of claim 39, where said checksum is calculated for the sub-object containing the region.

42. The computer-readable medium of claim 39, where said signature sub-object comprises a checksum algorithm identifier identifying the checksum algorithm used.

43. The computer-readable medium of claim 39, where each of said region specifiers comprises a checksum length.

44. The computer-readable medium of claim 37, where said signature sub-object comprises a signature algorithm identifier identifying a signature algorithm used for said producing of a digital signature.

45. The computer-readable medium of claim 37, where said signature sub-object comprises signer identifier identifying a signer for verification of said digital signature.

46. The computer-readable medium of claim 45, where said signer identifier comprises digital certificates

for securely identifying and verifying the public key of said signer.

47. The computer-readable medium of claim 37, where each of said region specifiers comprises a region offset identifying the start location of the corresponding region in a sub-object. 5
48. The computer-readable medium of claim 37, where each of said region specifiers comprises a region size identifying the size of the corresponding region in a sub-object. 10
49. The computer-readable medium of claim 37, where said object is a header object for an ASF file. 15
50. The computer-readable medium of claim 49, where said new object further comprises a GUID.
51. A computer-readable medium for use in combination with a digital object comprising at least one sub-object, said computer-readable medium validating a digital signature for at least one region, where each of said at least one region is comprised of all or part of one of said at least one sub-object, where an array comprises region specifiers for each of said at least one region, the computer-readable medium with instructions to perform acts comprising: 20
- identifying a region corresponding to each of said region specifiers; 30
- creating a data object comprising, said array and, for each of said region specifiers, said region corresponding to said region specifier, and validating said digital signature using on said data object. 35
52. The computer-readable medium of claim 51, where said object is a header object for an ASF file. 40
53. A computer-readable medium for use in combination with a digital object comprising at least one sub-object, said computer-readable medium validating a digital signature for at least one region, where each of said at least one region is comprised of all or part of one of said at least one sub-object, where an array comprises region specifiers for each of said at least one region, the computer-readable medium with instructions to perform acts comprising: 45
- determining the number of digital signatures present in said digital object; 50
- validating each of said digital signatures.
54. The computer-readable medium of claim 53, said computer-readable medium with instructions to perform acts further comprising: 55

returning an error value if the number of digital signatures present in said digital object is zero.

55. A memory for storing data for access by an application program comprising a data structure stored in said memory, said data structure adapted for storing verification information for an object comprised of at least one sub-object while allowing changes in the order of said sub-objects, comprising:
- a region specifier array comprising at least one region specifier, each such region specifier specifying a region comprising all or part of one of said sub-objects; and
- a digital signature for data comprising each of said regions and said regions specifier array.
56. The memory of claim 55, said data structure further comprising one or more of the following:
- a globally unique identifier (GUID) for said data structure;
- the size of the data structure;
- the number of regions in said region specifier array;
- a checksum algorithm identifier;
- a signature algorithm identifier identifying the algorithm used to produce said digital signature;
- a signature length for said digital signature; and
- signer information for verifying said digital signature.

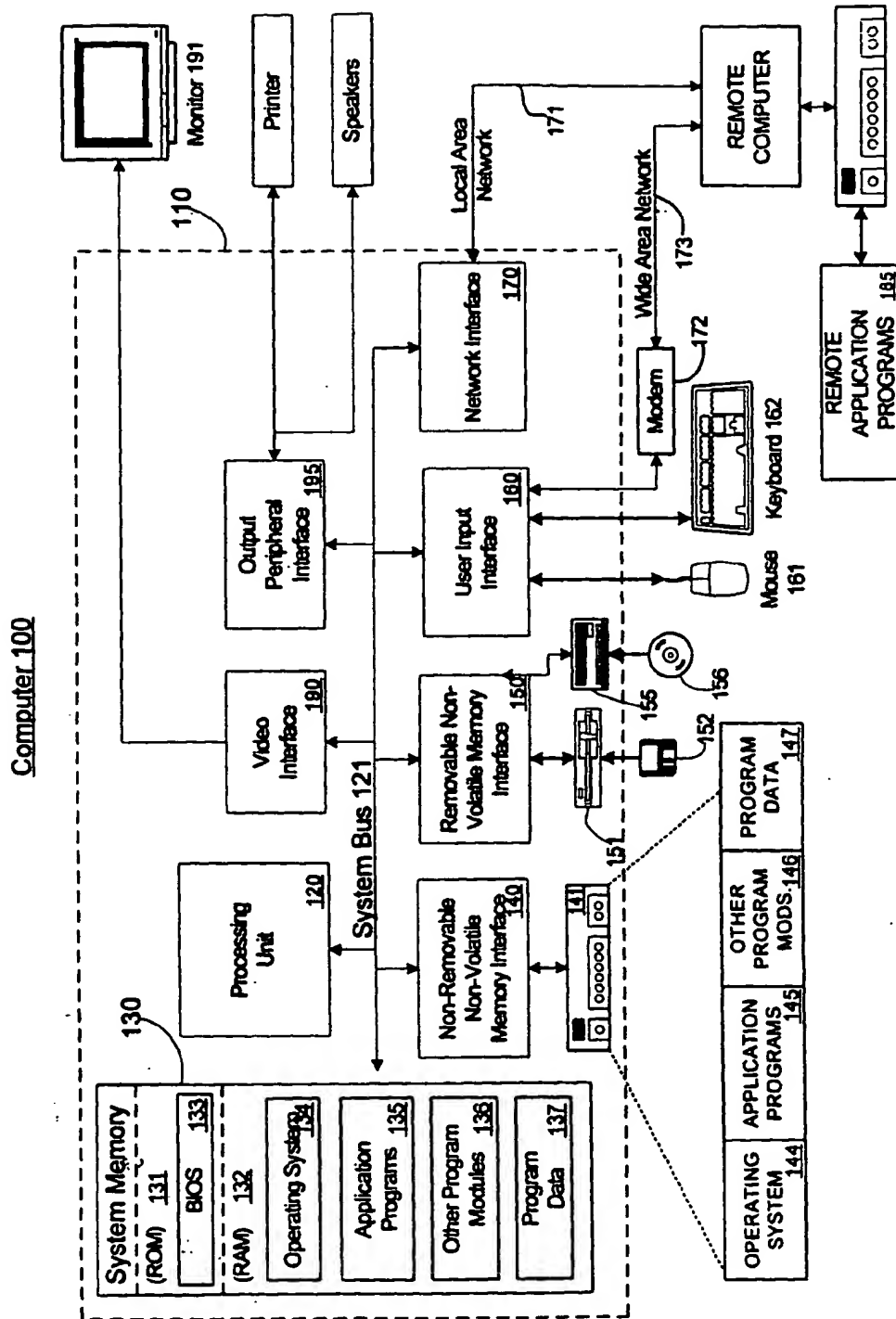


FIG. 1

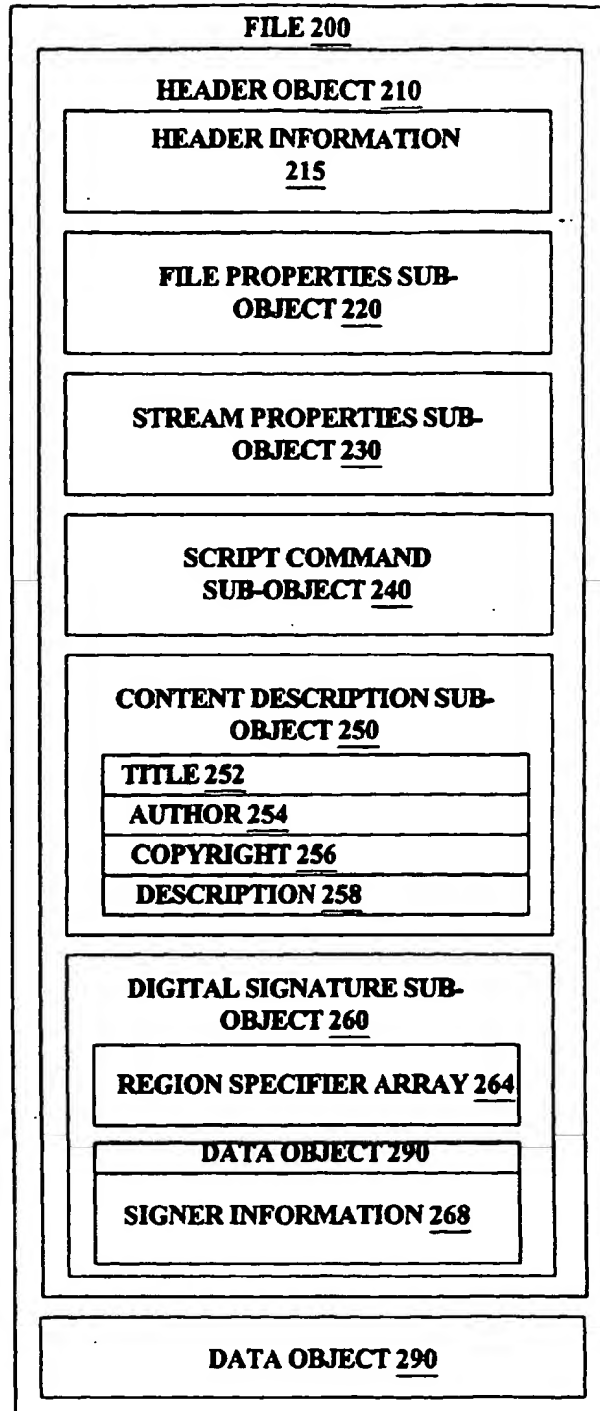


FIG. 2

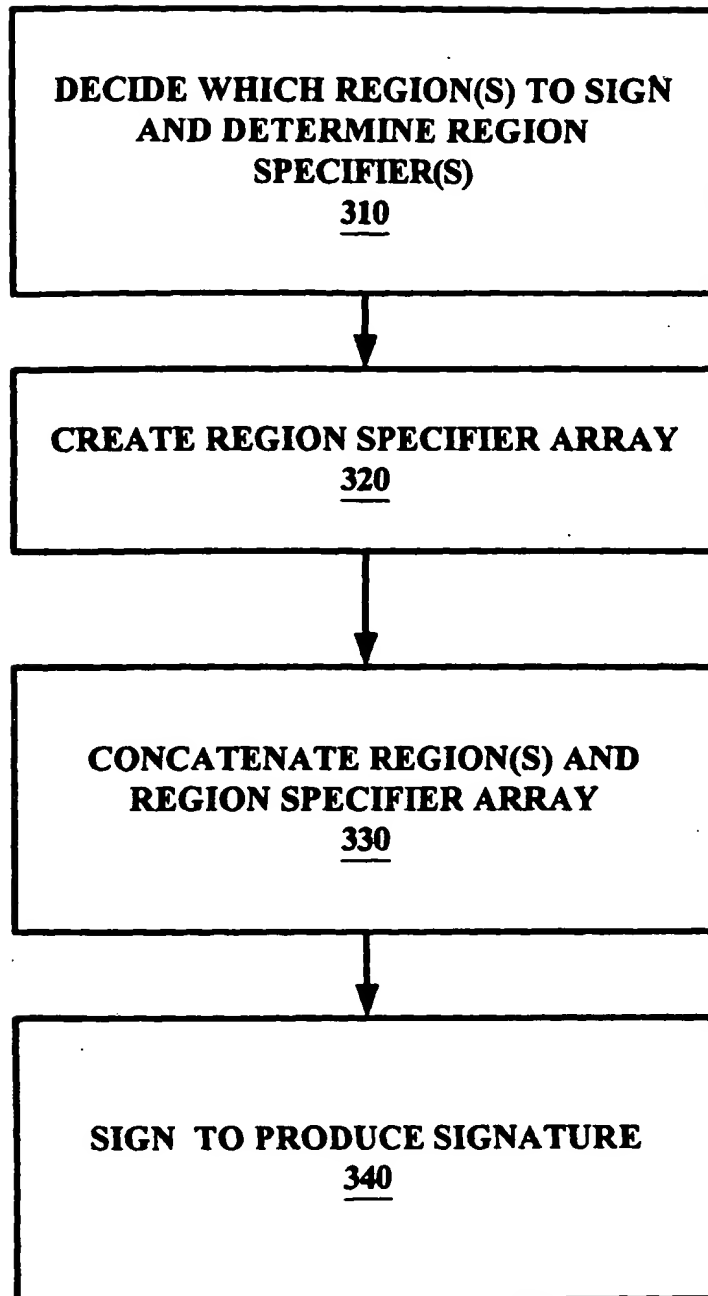


FIG. 3

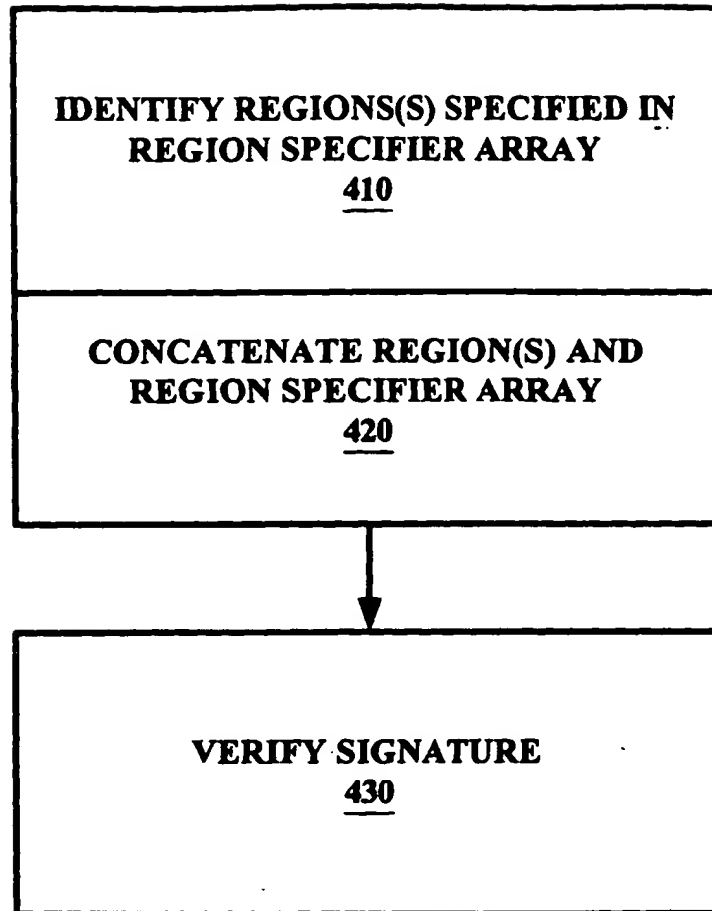



FIG. 4

Digital Signature Sub-Object 500



GUID <u>510</u>
Size of Digital Signature Sub-Object <u>520</u>
Number of Signed Regions <u>530</u>
Region Specifier Array <u>540</u>
Checksum Algorithm Identifier <u>550</u>
Signature Algorithm Identifier <u>560</u>
Signature Length <u>570</u>
Signature <u>580</u>
Signer Information <u>590</u>

FIG. 5